CLAIMS

We claim:

1. A catalyst comprising:

a porous substrate having an average pore size of from 1 μm to 1000 μm; and

disposed over the porous substrate, a zirconia-supported, alkali-metal-modified, ruthenium catalyst.

2. The catalyst of claim 1 made by steps comprising: impregnating zirconia with solution containing Ru and K, calcining, and reducing.

3. The catalyst of claim 1 comprising 0.1 to 10wt% Ru and 0.1 to 10wt% K.

4. The catalyst of claim 1 comprising a large pore support wherein at least 20% of the catalyst's pore volume is composed of pores in the diameter size range of 0.1 to 300 microns.

5. The catalyst of claim 4 characterized by a test in which the catalyst is tested by placement in a reaction chamber and contacted with a reactant gas mixture containing 8% CO, 7% CO_2, 38% H_2, and 47% H_2O, at a contact time of 50 ms and a temperature of 325 °C, it results in greater than 70% CO conversion and at least 80% CO_2 selectivity.

6. The catalyst of claim 1 characterized by a test in which the catalyst is tested by placement in a reaction chamber and contacted with a reactant gas mixture containing 8% CO, 7% CO_2, 38% H_2, and 47% H_2O, at a contact time of 25 ms and a temperature of 420 °C, it results in greater than 70% CO conversion and at least 80% CO_2 selectivity.

7. A method of producing hydrogen gas comprising:

flowing a reactant gas mixture into contact with a catalyst;

wherein the reactant gas mixture comprises carbon monoxide and water vapor;

wherein the catalyst comprises a zirconia-supported, alkali-metal-modified, ruthenium catalyst; and

forming hydrogen gas.

8. The method of claim 7 wherein the reactant gas mixture comprises 3 to 20% CO, 3 to 60% H_2O, 3 to 20% CO_2, and 10 to 60% H_2.

9. The method of claim 8 wherein the catalyst is at a temperature of 200°C to 420°C.

10. The method of claim 7 wherein the catalyst comprises a large pore support and the catalyst is at a temperature of 250°C to 350°C.

11. The method of claim 9 wherein said step of flowing is controlled so that the contact time is in the range of 3 to 100 milliseconds.

12. The method of claim 7 where the selectivity to carbon dioxide is at least 70% and the conversion of CO is at least 70%.

13. A reactor comprising:

a reactor inlet, a reaction chamber, a reactor outlet, and a microchannel heat exchanger;

wherein the reaction chamber contains a zirconia-supported, alkali-metal-modified, ruthenium catalyst; and

wherein the microchannel heat exchanger is in thermal contact with the reaction chamber.

14. The reactor of claim 13 wherein the reaction chamber has a width less than 2 mm.

15. The reactor of claim 14 wherein the heat exchanger is adjacent to the reaction chamber and wherein the heat exchanger has a width of less than 2 mm.

16. The reactor of claim 15 comprising at least two heat exchangers that are interleaved with at least 2 reaction chambers.

17. A fuel processing system comprising the reactor of claim 13.

18. A hydrogen production system comprising:

a fuel tank;

a primary conversion reactor capable of converting fuel to produce carbon monoxide;

wherein the primary conversion reactor comprises a fuel inlet, a primary conversion reactor chamber and an exhaust outlet;

a water gas shift reactor comprising a shift reactor inlet, a reaction chamber, and a shift reactor outlet;

wherein the shift reactor inlet is connected to the combustor exhaust outlet; and

wherein the reaction chamber contains a zirconia-supported, alkali-metal-modified, ruthenium catalyst.

19. The hydrogen production system of claim 18 further comprising a fuel cell to form a fuel processing system.

20. The hydrogen production system of claim 18 further comprising a secondary CO clean up system.

21. The hydrogen production system of claim 20 further comprising a fuel cell to form a fuel processing system.